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KINESTHETIC APPROACHES TO TEACHING MATH:
TEACHERS' PERCEPTION OF HAND GESTURE BASED MATH VIDEOS

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Kinesthetic Approach to Teaching Math: Teachers' of Hand Gesture Based Math Videos

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ABSTRACT

This study aims to explore the creation of hand gestures-based math videos and teachers' perceptions of introducing them in their math lessons. The videos are grounded in a kinesthetic and creative approach to math education, which is suggested to be beneficial for learning. Following the creation of three math dance videos, three math teachers introduced the videos to their classes and were interviewed on their perceptions of this approach to math education. The teachers have shown interest in this approach and its potential benefits, and would like to be more informed and trained on such approach. Further research on teachers' professional development as well as retention of knowledge by students is recommended.

Keywords:

math education, mathematics, kinesthetic learning, hand gestures, memorization

CONTENTS

1 INTRODUCTION

Mathematics lessons in secondary school are not often associated with creativity. There is a final exam at the end of the year, in most cases mandatory, and a long list of topics to cover, practice and memorize. Lessons are counted and time is precious, and teachers have less room for artistic initiatives that might refresh the subject's image.

I have been personally involved in secondary math education for the past ten years. During this time, I have taught different classes and levels at secondary schools according to various programs, regional requirements and national curriculum. As a math teacher, I felt that my main challenge was to create a positive experience around math education by using digital literacy or a kinesthetic learning approach; in most cases students are required to take a final and mandatory exam in math regardless of their level, which leads to a mixed and negative feeling towards this subject.

The year plans and syllabi are well structured and detailed, and leave little room for personal interpretation or initiatives from the teachers' side, as they depend on many factors such as available resources, number of weekly hours, training and professional development budget, tech equipment and devices available for both teachers and students, internet access etc. Promoting digital literacy in math lessons using various types of media and software can be either embraced or tested by early-adapting teachers or face unwillingness of others who perceive additional digital tools as supplementary rather than essential.

Furthermore, introducing a new approach in class may take up precious teaching time which is dedicated to cover materials included in the matriculation or final exams. Class textbooks, worksheets and frontal teaching seem to be the common teaching methods. And since the syllabi and matriculations exams remain unchanged, there is no burning need to modify the existing curriculum and supporting materials as well.

One example of a creative and kinesthetic teaching approach that inspired the work summarized in this article is the AIM method[1]. The AIM method (Accelerative Integrated Methodology), founded by Wendy Maxwell, teaches languages using visual, auditory

[1] AIM Language Learning official website https://www.aimlanguagelearning.com

and kinesthetic tools. Its core idea is that each word is represented by its own unique hand gesture so that it supports memorization and the acquiring of new terms. This research explores whether this approach can be used in math classes as there are also cases where memorization of terms and concepts are required.

“Math is taught as a set of procedures and calculations, when brain research tells us that visual representations and ideas are really important for brain connections and mathematical growth. Visual math tasks enable learners to be creative, and to see the beauty in math” (Boale, 2017). My research will examine a case study of hand gestures and dance videos which I developed, edited and composed myself, to explore the extent to which they are practical for math lessons.

2 THEORETICAL BACKGROUND

This section describes the theoretical background that inspired *Movemathics*[2], the hand gesture-based math dance videos which I have created. As the title suggests, the videos comprise a combination of movement and mathematics. The videos are a combination of kinesthetic approaches that create a social experience in class that may support both memorization of required elements and give teachers more room to promote creativity and mathematical mindset. The following theory resources describe the connection between kinesthetic learning to memorization skills and social benefits in class, as well as teachers' capabilities and readiness of bringing such an approach into their classrooms.

2.1 Learning Styles

Learning styles refer to the methodology of learning, how to approach the learners and what senses and processes are involved in the learning process. The VARK model (Fleming, 2001) stands for for the following:

- Visual: graphs, charts, colors, pictures and other visual elements.
- Auditory: frontal lectures, discussions, recordings, audio reports.
- Read/Write: texts, reports, essays, handouts, web pages.
- Kinesthetic: outdoor trips, physical activity, experiment, hands-on approach.

Students may be inclined to prefer one learning style over another, according to their own personal skills, desires and tendencies. There is no right or wrong learning style, and in a heterogeneous group, it is recommended that different learning styles be used. Teachers can identify the different needs and address them in their lesson plan by introducing different types of activities or demonstrations that might increase students' engagement.

[2] Movemathics project website: https://bermanon.wixsite.com/movemathics

2.2 Perfomative Teaching

Martinez (2017) describes in his book that the key to success in math education is combining communication, social and emotional skills and playful and performative teaching methods. The challenge is to update and modify the current teaching practices by creating new interdisciplinary practices that were not previously supported.
Communication skills can be encouraged by the act of ensemble performances or creative group collaborations. Technology can be used to create those opportunities, whereby students can communicate, express themselves, distribute knowledge and exchange ideas. The technology supports bringing students together as a group and developing collaborative relationships.

2.3 Mathematical Mindset

Boaler J. and Dweck C. (2016) write about mathematical mindset and describe multiple approaches and activities to support and develop their theories. They distinguish between a growth mindset, which is smartness and skills increase with hard work, and a fixed mindset which says that although new knowledge can be acquired, basic levels of intelligence cannot be changed.

Mindsets lead to learning behaviors and patterns, which can result in different learning outcomes. Changing people's mindsets can change their learning pathways. A common misconception is that mathematics is a subject of right and wrong answers with no place for creativity, therefore it could be considered as threatening. Another misconception is that excelling in mathematics is the privilege awarded to students with higher intelligence.

These two misconceptions are refuted by Boaler J. and Dweck C. (2016); mathematics is constantly evolving and requires reasoning, creativity, interpretation and connection making. Furthermore, mathematics abilities can be acquired, taught and be modified throughout one's school career. No one is born with a mathematical knowledge or with a lack of it. Students with a fixed mindset are more likely to struggle, whereas students with a growth mindset will show more persistence when trying to solve a problem. The latter has more positive brain activity and openness to learn from mistakes or when given feedback. Therefore, using various creative activities and approaches, teachers can

encourage and support students' intellectual freedom and develop students' growth mathematical mindset.

2.4 Social Emotional Learning

The Collaborative for Academic, Social, and Emotional Learning (CASEL) Guide (2015) defines Social Emotional Learning (SEL) as “the process through which children and adults acquire and effectively apply the knowledge, attitudes, and skills necessary to understand and manage emotions, set and achieve positive goals, feel and show empathy for others, establish and maintain positive relationships, and make responsible decisions." When school becomes a healthy and safe place for students, they identify themselves as part of a collective with common thoughts and goals (Haynes, 2003). Because they feel secure as learners, they are more likely to try out new ideas and share them in larger groups. Instructional activities have a great impact on students' engagement and interest in mathematics, and therefore the knowledge of youth development should be taken into consideration when planning such activities, so that generative relationships between students can help sustain the learning process.

According to Ben-Avie, Eren, Newton (2003), youth development is active and best propelled by adult supervision (the teacher in class) and through group interaction and teamwork. Students’ performance in mathematics class may be influenced by their sense of self-confidence and a respectful relationship between class members. These qualities can be promoted when more group work and learning activities are embedded in lesson plans, encouraging students to engage with each other and with adults. The researchers saw a strong relationship between the social and emotional development of students and the increased likelihood of academic achievement. In all their observations of schools, students' social and emotional skills strongly correlated with problem-solving skills in mathematics.

2.5 Embodied Pedagogy

Embodied learning theory explores pedagogies that connect sensory, motoric and intellectual engagement on learners (Gerofsky, 2010). The abstract nature of mathematics makes it more challenging to be represented and expressed. Gerofsky and fellow researchers noticed that learning mathematics stimulated a bodily experience among learners, as learners try to find real representation in concrete objects or imagine

virtual objects. One aspect of embodiment is gestures: "movements of hands, face and other parts of the body employed in a largely unconscious way for non-verbal communication" (Gerofsky 2010). People who are engaged in a physical experience or performance-based activities stimulate different neuronal areas of the brain than those who simply watch or listen to a description of an activity. The common perception is that in mathematics lessons students are rewarded if they sit quietly, do correct calculations, take notes and document their work. Movement, music and sensory experiences for explorations are not aligned with the existing teaching methods or materials. Disembodied approach was favored over sensory representations and kinesthetic approach. Recently, an increased attention to multisensory and embodied ways of learning has become more noticeable. Gerofsky identifies a place for new pedagogical methods using embodied and multisensory facets of mathematical learning together with the right balance of symbolic, graphic numeric and verbal representations.

Goldin-Meadow, Franconeri, Congdon, Novack, Wakefield (2018) investigated the effect of hand gestures on memory. Their findings indicate that students perform significantly better after learning through speech and gesture instructions than through speech instructions alone. They noticed that watching gestures assist children to synchronize their visual attention with the information presented in the instructor's speech than children who follow a no-gesture pedagogy. The research showed that mathematics instructions through gestures facilitate better learning than speech alone, and are useful in guiding students' visual attention which can positively predict positive learning outcomes. Goldin Meadow and Cook (2010) showed that when people talk and gesture, they add an action component to talking which makes the information more memorable for them than when talking without gestures. Talking with gestures also leads to a better recollection of information. Thus, gesturing seems to play an active role in facilitating memory.

Abrahamson and Lindgren (2014) discussed the main challenges when designing activities using embodied design. After preparing and teaching proportion in math class using hand and finger gestures, they discussed what would make such instruction effective. One idea was initial short assignments that favor figurative or graphical representation, followed by clear and straightforward instructions for students to use their perceptual senses. Quigley, Herro, and Baker (2019) identified several challenges of teachers when trying to incorporate art related activities into math lessons: the amount of collaboration that this pedagogy requires, lack of updated teaching resources and professional development opportunities, and unclarity regarding the concrete connection

between the artistic elements and the mathematical content. The study showed that a clear curricular design and instruction scheme may lead to more clarity and confidence amongst teachers who implement new methods in class.

2.6 Impact of Embodied Pedagogy on Memorization

In "Measuring Innovation in Education"- a report published by the Organization for Economic Co-operation and Development (OECD) (2019), the relevance of memorization as a pedagogical method is discussed and questioned. Learning by memorization is a traditional pedagogical method and considered to be opposed to active learning and therefore relatively teacher-centered. However, memorizing rules, facts and procedures is part of all learning strategies to different extents. Applying formulae and rules correctly is a technical skill that students are required to learn. Memorizing for the sake of knowing by heart would not lead to any cognitive development and does not stand alone if not applicable. The report found that a right balance between memorization and active learning is recommended and should be monitored by the teacher. An increasing emphasis on memorization pedagogy on the other hand, is associated with the existence of high-stake exams and assessments.

3 DEVELOPMENT OF HAND GESTURES-BASED DANCES

The theoretical background outlined above inspired me to a development of a series of mathematical dances that combine different elements to address different types of learning:

- Visual: all elements are marked with distinct colors.
- Auditory: catchy music, the lyrics are solely mathematical terms or letters of a formula, no additional text.
- Kinesthetic: simple routine of hand gestures.

The dance routine itself is less than 15 seconds long. The decision of the 15 second long duration was made according to social media apps, such as Instagram, where videos of up to 15 seconds can be uploaded and shared.

The dance routine repeats itself twice; the second part is a bit faster, louder and with more graphic elements to increase interest and finish on a more exciting note. The development process examined three types of hand-gestures based dances, each one was named differently (in brackets):

3.1 Geometric Positions: Right Triangles Trigonometry (TrigoDance)

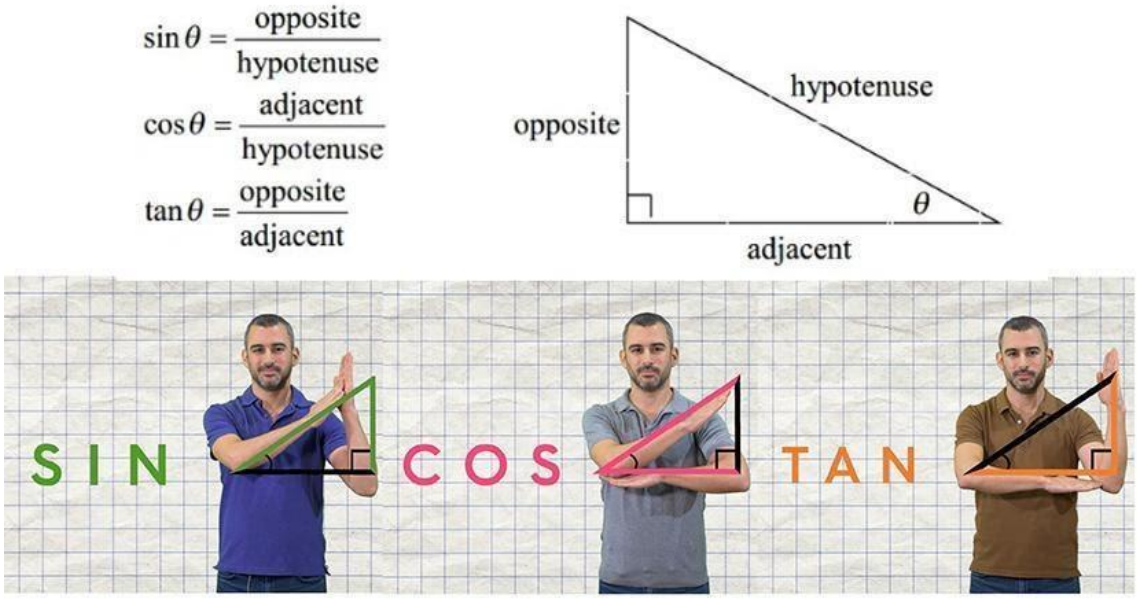


Figure 1: TrigoDance: Geometric positions represented by hand gestures

The hand gestures represented the three trigonometric functions in right triangles.

3.2 Algebraic Formula: The Quadratic Formula (Parabolala)

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Figure 2: Quadratic formula components represented by hand gestures

The hand gestures represented letters and arithmetic operations:

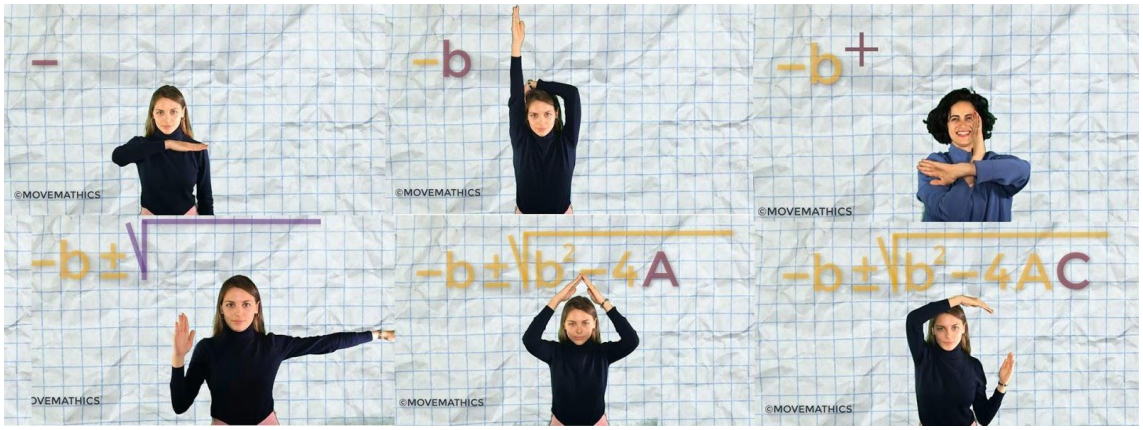


Figure 3: letters and operations key

3.3 Sign Manipulation: Multiplying and Dividing by Negative Numbers (What's Your Sign?)

Sign	+	-
+	+	-
-	-	+

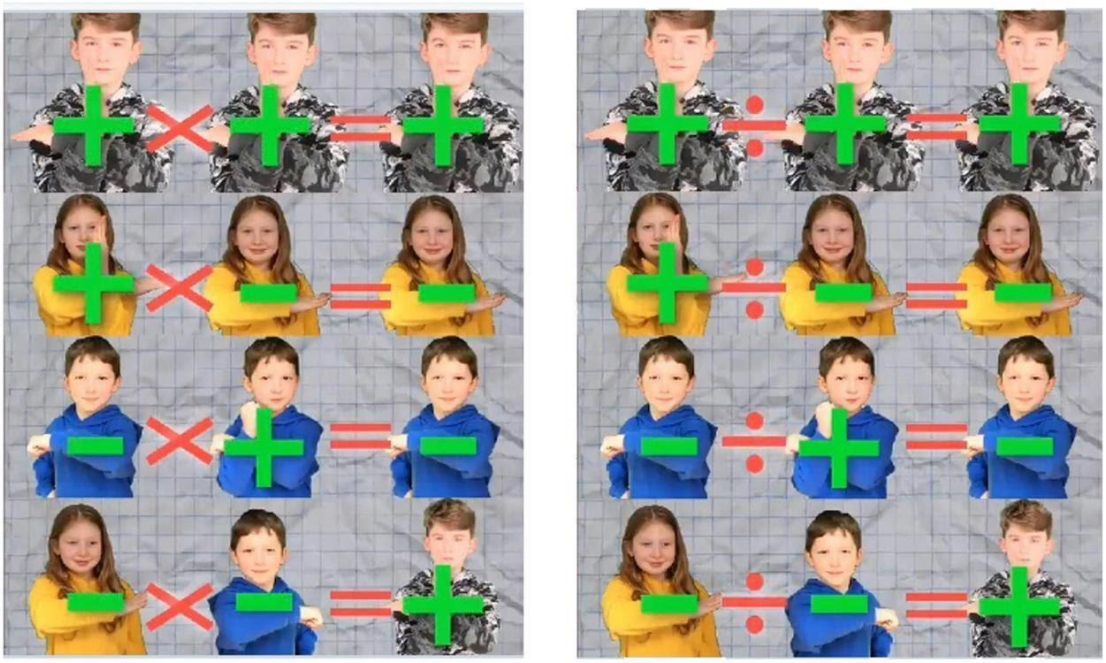


Figure 4: Multiplication and division by negative numbers table

A sequence of 3 signs represented by hand gestures; presented separately for both multiplication and division.

4 METHODS

The study follows teachers' experiences in using the math dance videos in their lessons, and summarizes their personal experiences while introducing this type of media to their class, as well as general impressions for any sign of influence on their students.
The study includes an activity plan (Appendix 1) for teachers that explains how to introduce the math dance activity to their classes. Three math teachers have participated in the study and given their consents to implement the activity in their lessons:

Teacher	Grade	Number of students in class	Theme	Location
1	*8*	38	TrigoDance	Israel
2	9	32	Parabolala	Israel
3	8	24	TrigoDance	Spain

Table 1: List of teachers participating in study

Qualitative research based on interviews was chosen as a methodology to explore what the teachers had experienced. Class observations and note-taking at the presence of students require further administration and bureaucracy, therefore the teachers have agreed to give their consent to participate in a face-to-face or video conversation before and after their lessons. Furthermore, one time observation is not enough to determine the influence of the math dances activities in comparison to the routine atmosphere and students' engagement in class.

With all three teachers a preliminary phone call was held to explain how to introduce the math dances videos in their lessons. The key prompts for use were:

- The videos can be played either at the end of a teaching session, showing a different angle to look at the material that had just been taught, or at the beginning of a following lesson, as a starter/ reminder.
- Teachers can replay the videos and ask their students to try out themselves. Students can remain seated, stand or just choose a place in class where they feel comfortable.
- Teachers can allocate time in class and let the students create their own interpretation: prepare their own video, poster or other variation.

Following the class activity the teachers led, I had another follow-up interview with each teacher. I met teacher 1 and Teacher 2 in person at their school; while I had an an online Skype interview with Teacher 3. The purpose of the interview was to collect teachers' perceptions about their experience with using math dance videos, as well as hear more about their professional background and current work conditions and norms. They were asked open-ended questions (Appendix 2) and the interviews' audio was recorded. All three teachers have given their verbal consent to have the audio recorded and used for transcription purposes only; the interviews' audio files were erased after the interviews had been transcribed and coded.

Each interview was transcribed and then analyzed according to the inductive coding methods (Thomas 2003): reading through the teachers' answers, similar and related motives and ideas could be clustered under specific categories which are described in detail in the following section.

5 RESULTS

The teachers' answers could be clustered in eight different categories as follows:

5.1 Preparation Work

In terms of lesson plans, documents and other assisting materials that teachers prepare and review before the lesson, all teachers note that having a set of questions to model and have students practice is essential. As one teacher mentions, "I present an introduction exercise and then assign classwork that I've preselected." However, each class is different and teachers also feel the need to "leave space for additional tasks and questions that students might come up with."

5.2 Routine activities

All three teachers highlight the lack of flexibility in their lesson activities. With the exception of one teacher who "[screens] once or twice a year a TED talk," most of the lesson activities consist of exercises from "[students'] course book and "a question bank that we can use." However, flexibility is possible in the format of the activities. One teacher changes things up for students by "[giving] them some time for group or pair work."

5.3 Equipment

Many teachers feel that there is a lack of technology support and equipment in their classroom. In terms of available devices that teachers can use at their schools, one mentions that not all rooms are equipped with a projector, and that these rooms often need to be booked in advance. At one school, which "every room has a smartboard, the speakers are a different story." One teacher also faces the issue of unreliable internet connection. Cell phone use varies from school to school, with one school not allowing cell phones in class while another school implements a "silent mode" rule that prohibits students from using their phones during class.

5.4 Tech Proficiency

Teachers' level of comfort and proficiency with technology use presents another challenge. While there is a Bring Your Own Device policy in one school, the teacher mentions that "in math classes [the students] use course books and write in their notebooks." Technology, according to one teacher, serves as "a supplementary work, and in very specific cases."

5.5 Routine class atmosphere

All three teachers share similar sentiments about the class atmosphere. As one teacher states, "my lessons are well-structured yet repetitive." Another teacher attributes the problem to the limited number of lessons and "time pressure to cover the syllabus." As a result, students are put through rigorous lessons and feel stressed out.

5.6 Atmosphere after using math dances class

After the teachers try the math dances in class, they report an overwhelmingly positive feedback. Students are reported "amused and already started moving in their seats." The teachers also appreciate that students show a clear interest and "started creating something they want to share with others." One teacher mentions that "some [students] were indeed reluctant, however, they did not show resistance and watched the others interact," suggesting that this format might not appeal to all learners.

5.7 Operational and implementation aspect

Regarding the implementation of videos and screening them in class, the teachers are happy with the results and add that it also reduces the workload for the teachers. As one teacher says, "it did not require much and was very beneficial." On the other hand, some teachers still struggle with the time constraint, noting that "I could not spare too many minutes of class time," and feel unsure of how to incorporate more multimodal activities into their lessons. An important note is that teachers view the math dances as a "positive buzz" that while refreshing, "cannot always be implemented in class."

5.8 Professional development opportunities

Finally, I asked about professional development opportunities to gauge how teachers learn about new trends and methods to incorporate in their lessons. The answers vary from a monthly department meeting to an annual national education conference. One teacher professes to “using the same materials for years” because it has worked well. This suggests that math teachers are not incentivized to implement changes to their instructions.

6 DISCUSSION

As Martinez (2017) described, a successful implementation of art related activities which are less common in math classes depends on the willingness of the teachers to embrace a performative approach. When asking students to engage in an art-related task, such as math dance, it may be more beneficial if the teachers take an active part in it as well. Based on the interviews, all teachers indicated a degree of discomfort in engaging themselves into the activity: they appreciated the innovative and new approach of presenting technical terms, however were not inclined to perform and demonstrate in front or together with the students.

AIM method states on their website that “Teacher Training + Resources = Success”. Registered and certified teachers have access to a repository of resources and frequent training for teachers are offered as well. The main goal is to help teachers build and develop their efficacy and confidence when using new methods and resources. My math videos were all stand-alone units without being fully integrated in any work plan, which did not allow teachers much room for creativity and their self expression. Introduction of a new activity or method, even a short assignment as screening a video as described in section 3, should be communicated and explained clearly before teachers get to practice it in class. The teachers described how their preparation and alignment role plays a significant role in their routine. This is also supported by the research of Quigley et al. (2019) who stressed the importance of curriculum context and structure methodology to support teachers’ preparations, or else it is considered a gimmick.

Furthermore, there seems to be a need for a diverse set of exercises in math lessons besides the continuous exercise list and test preparations. The teachers describe the math dances activities as a fresh breeze that promotes creativity, active participation and social interaction which are less identified with math lessons.

7 CONCLUSIONS

This was a preliminary attempt to combine elements from dance, art and the creative world and incorporate them in math lessons. My focus and target group were the teachers themselves as they are the ones who not only teach and deliver the content, but also build trust and personalize their own teaching philosophy into each of their lessons. Furthermore, I wanted to get an impression of whether there is room to use a new type of media in math lessons and how practical teachers find it and what are the challenges they face.

As new trends and tools are emerging, and students consume information and develop their learning styles and methods, there is a growing need for teachers to get continuous and frequent support to enable their work to become more up-to-date and relevant to their target audience, the students.

Curriculum and matriculation exams may be a benchmark which will stay in the foreseeable future, nevertheless the ways to teaching and reaching the end point of the learning journey is what can be developed and changed. The teachers who were interviewed shared that despite the hard requirements and time limitation of the education system, there is room for creativity in math lessons. The main challenge is to find the right way to incorporate new types of activities into existing and well-thought out lesson plans.

Aside from diversifying teaching methods, there is also a place to explore whether hand gestures do support both students' memorization skills and motivation in class. Both indicators were positive, however I can recommend a deeper and further exploration on the students' side as well.

I would like to conclude with a quote said by one of the teachers that I interviewed: "It was the perfect way to wrap up the lesson and let the students leave the classroom smiling". Math lessons, and school in general, can offer a whole new experience and be taught in innovative ways from which both teachers and students can benefit.

8 REFERENCES

AIM Language Learning, What Is AIM? (2017), Retrieved from: https://www.aimlanguagelearning.com/what-is-aim/

Abrahamson, D., & Lindgren, R. (2014). Embodiment and embodied design. The Cambridge handbook of the learning sciences, 2, 358-376.

Boaler, J. (2015). Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching. John Wiley & Sons.

Cook, S. W., Yip, T. K., & Goldin-Meadow, S. (2010). Gesturing makes memories that last. Journal of memory and language, 63(4), 465-475

Fleming, N., & Mills, C. (2001). VARK: A guide to learning styles.

Gerofsky, S. (Ed.). (2018). Contemporary Environmental and Mathematics Education Modelling Using New Geometric Approaches: Geometries of Liberation. Springer.

Gerofsky, S. (2013). Learning mathematics through dance. In Proceedings of Bridges 2013: Mathematics, Music, Art, Architecture, Culture (pp. 337-344). Tessellations Publishing.

Gerofsky, S. (2010). Mathematical learning and gesture: Character viewpoint and observer viewpoint in students' gestured graphs of functions. Gesture, 10(2-3), 321-343.

Goldin-Meadow, S. (2006). Talking and thinking with our hands. Current directions in psychological science, 15(1), 34-39.

Hardiman, M., Rinne, L., & Yarmolinskaya, J. (2014). The effects of arts integration on long-term retention of academic content. Mind, Brain, and Education, 8(3), 144-148.

Harding, T., & Whitehead, D. (2013). Analysing data in qualitative research. Nursing & midwifery research: Methods and appraisal for evidence-based practice, 141-160

Haynes, N. M., Ben-Avie, M., & Ensign, J. (Eds.). (2003). How social and emotional development add up: Getting results in math and science education. Teachers College Press.

Howison, M., Trninic, D., Reinholz, D., & Abrahamson, D. (2011, May). The Mathematical Imagery Trainer: from embodied interaction to conceptual learning. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1989-1998)

Jiying Han & Hongbiao Yin | Mark Boylan (Reviewing Editor) (2016) Teacher motivation: Definition, research development and implications for teachers, Cogent Education

Martinez, J. E. (2012). A performatory approach to teaching, learning and technology (Vol. 34). Springer Science & Business Media

Newton, D. A., Eren, R., & Ben-Avie, M. (2013). Technology in Action. Journal of Special Education Technology, 28(2), 53–56.

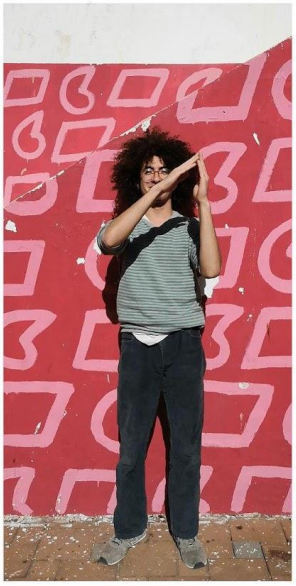
Quigley, C. F., Herro, D., & Baker, A. (2019). Moving Toward Transdisciplinary Instruction: A Longitudinal Examination of STEAM Teaching Practices. In STEAM Education (pp. 143-164). Springer, Cham.

Thomas, D. R. (2003). A general inductive approach for qualitative data analysis.

Vincent-Lancrin, S., et al. (2019), Measuring Innovation in Education 2019: What Has Changed in the Classroom?, Educational Research and Innovation, OECD Publishing, Paris

Wakefield, E., Novack, M. A., Congdon, E. L., Franconeri, S., & Goldin-Meadow, S. (2018). Gesture helps learners learn, but not merely by guiding their visual attention. Developmental science, 21(6)

APPENDIX 1: STUDENTS' WORKS



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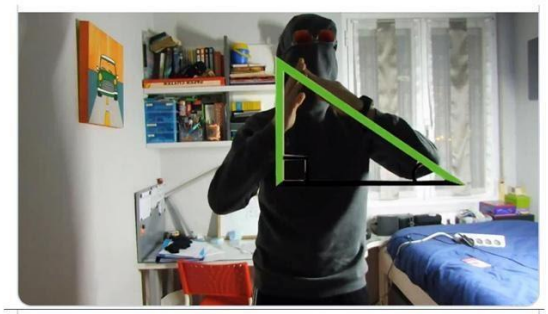


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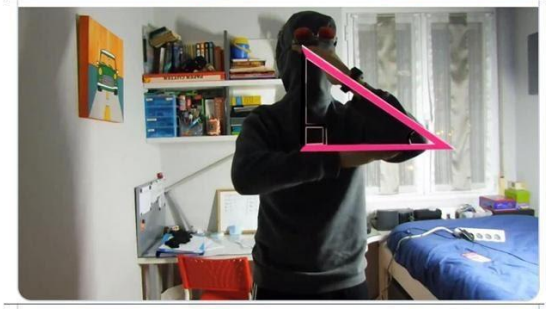


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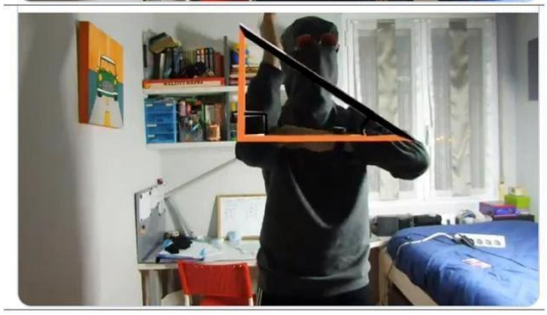


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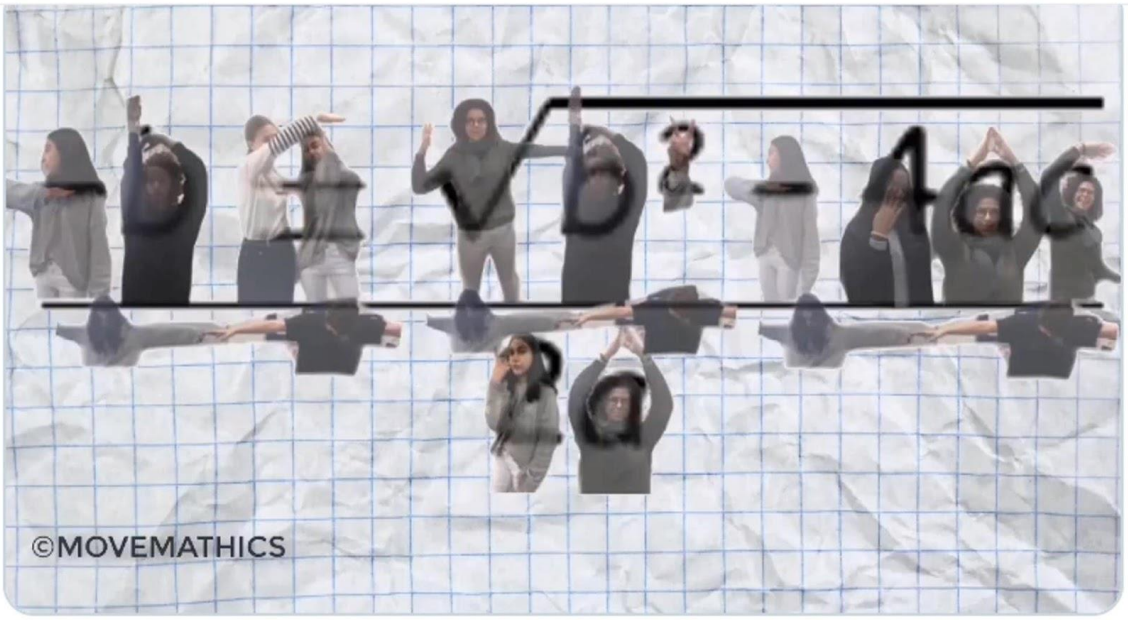
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APPENDIX 2: INTERVIEW QUESTIONS

- How do you decide which supplementary material you use in your lessons?
- When using supplementary material, what teaching objective does it support?
- Do you show videos or use other types of media in class?
- Are smartphones allowed at your school?
- Do all classes at your school have internet access?
- Are you familiar with any EdTech or learning app?
- What factors would encourage you to use supplementary material?
- Why is memorization of a formula important for students? How does it support their math studies?
- From your experience, what was the most effective way for students to memorize concepts?
- How comfortable were you in introducing math-dance videos to your class?
- How did you run the exercise in your class?
- How was the students' reaction?
- Which teaching objective was most effectively targeted?
- In which part of the lesson should the videos be introduced?
- Could you notice any difference in the following lesson?
- Would you introduce such activity again in your lessons?
- How do you share resources with your colleagues?
- Do you have the freedom to create new types of activities?
- How often do you attend a professional development training?